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Sturm

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(54) **FLUID HEATING SYSTEM**

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(51) **Int. Cl.**
F24H 1/10 (2006.01)

(52) **U.S. Cl.** **392/478**; 392/479; 392/503

(58) **Field of Classification Search** .... None
See application file for complete search history.

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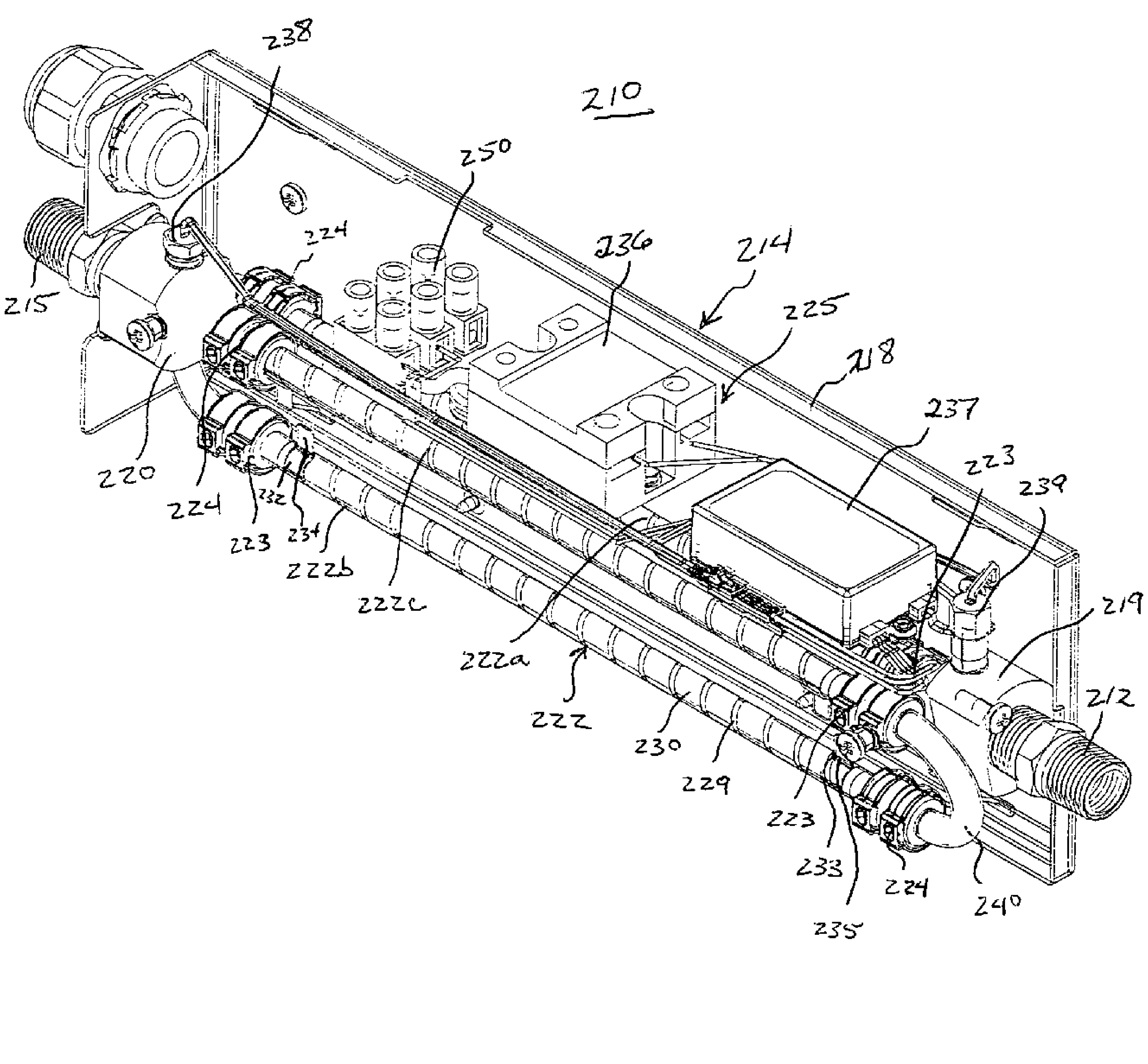
(74) *Attorney, Agent, or Firm*—Parsons & Goltry; Robert A. Parsons; Michael W. Goltry

(57) **ABSTRACT**

A fluid heating system includes a fluid supply conduit, a hot fluid conduit, and a fluid heating tube assembly. The fluid heating tube assembly includes an inlet coupling coupled to the fluid supply conduit, an outlet coupling coupled to the hot fluid conduit, and at least one fluid heating tube coupled between the inlet coupling and the outlet coupling. The at least one fluid heating tube includes a tube formed of heat conducting material, a dielectric coating permanently bonded on an outer surface of the tube, and a resistive layer permanently bonded on the dielectric coating. A power distributor is coupled to the fluid heating tube assembly and coupleable to a power source. A switch is coupled between the power distributor and the fluid heating tube assembly to control current flow from the power distributor to the at least one fluid heating tube.

24 Claims, 13 Drawing Sheets



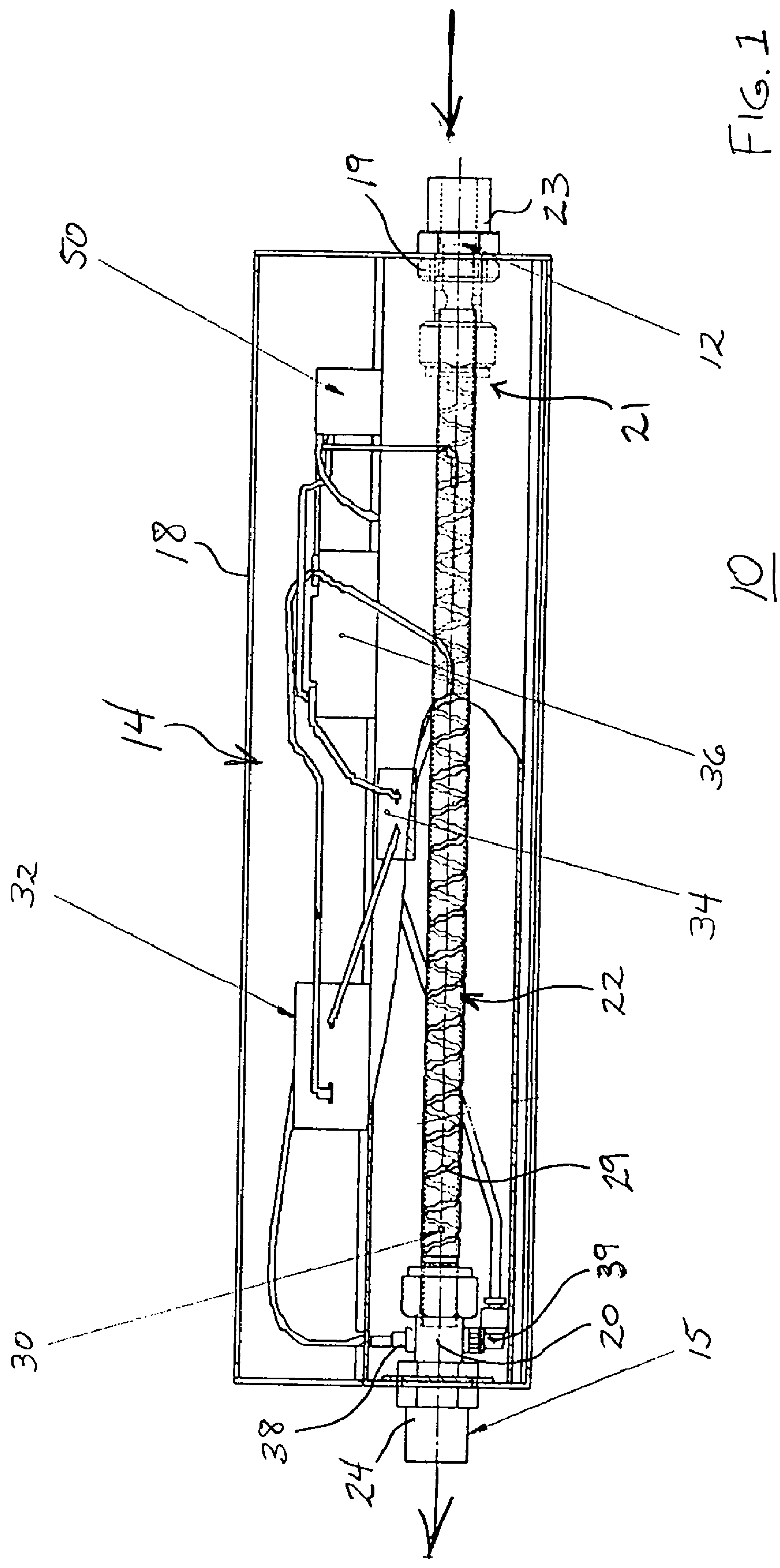
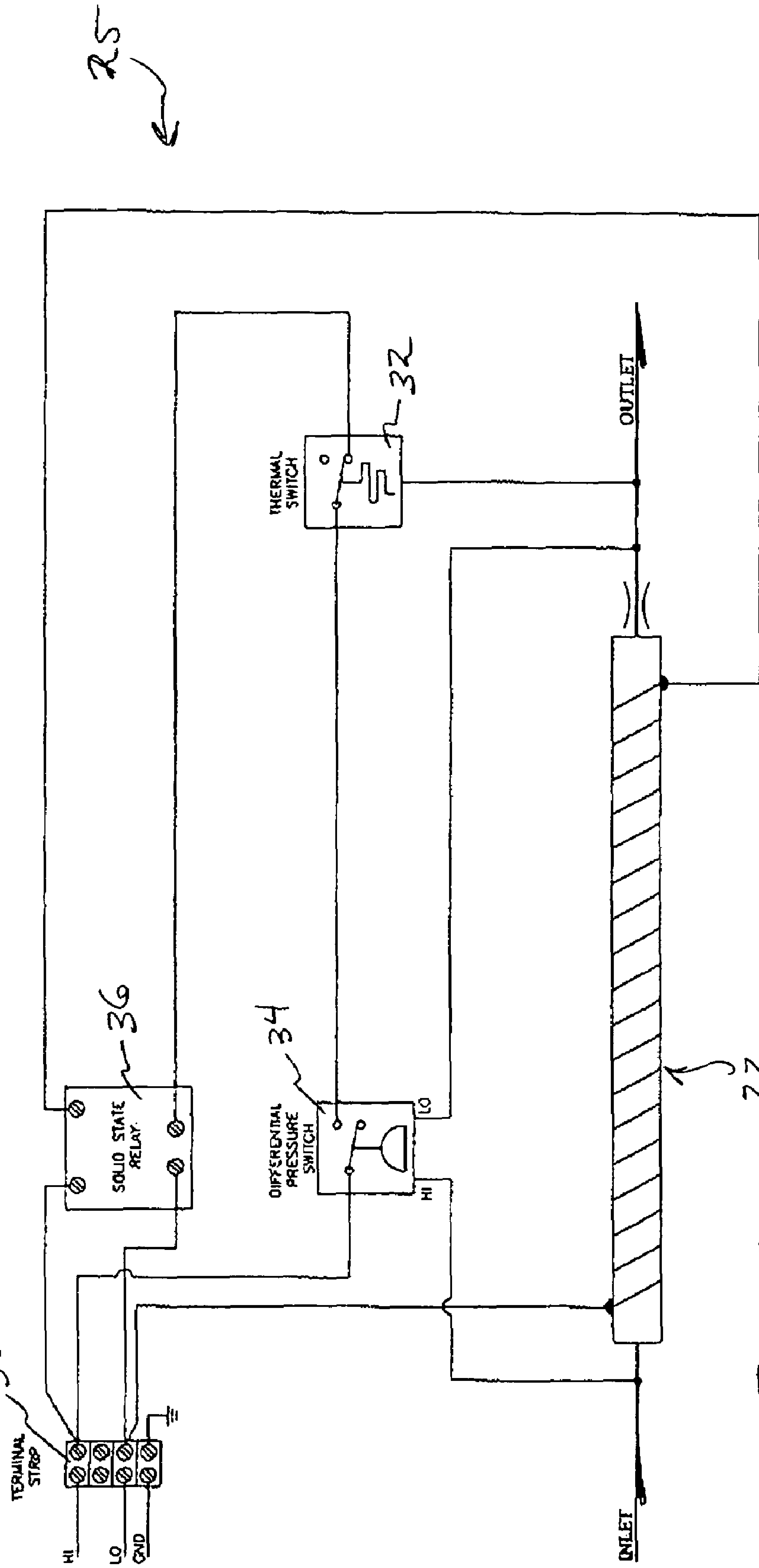


FIG. 1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THERMAL SWITCH
32
OUTLET
SOLID STATE RELAY
36
DIFFERENTIAL PRESSURE SWITCH
34
LO
HI
22
50
TERMINAL STRIP
HI
LO
GND
INLET

FIG. 2

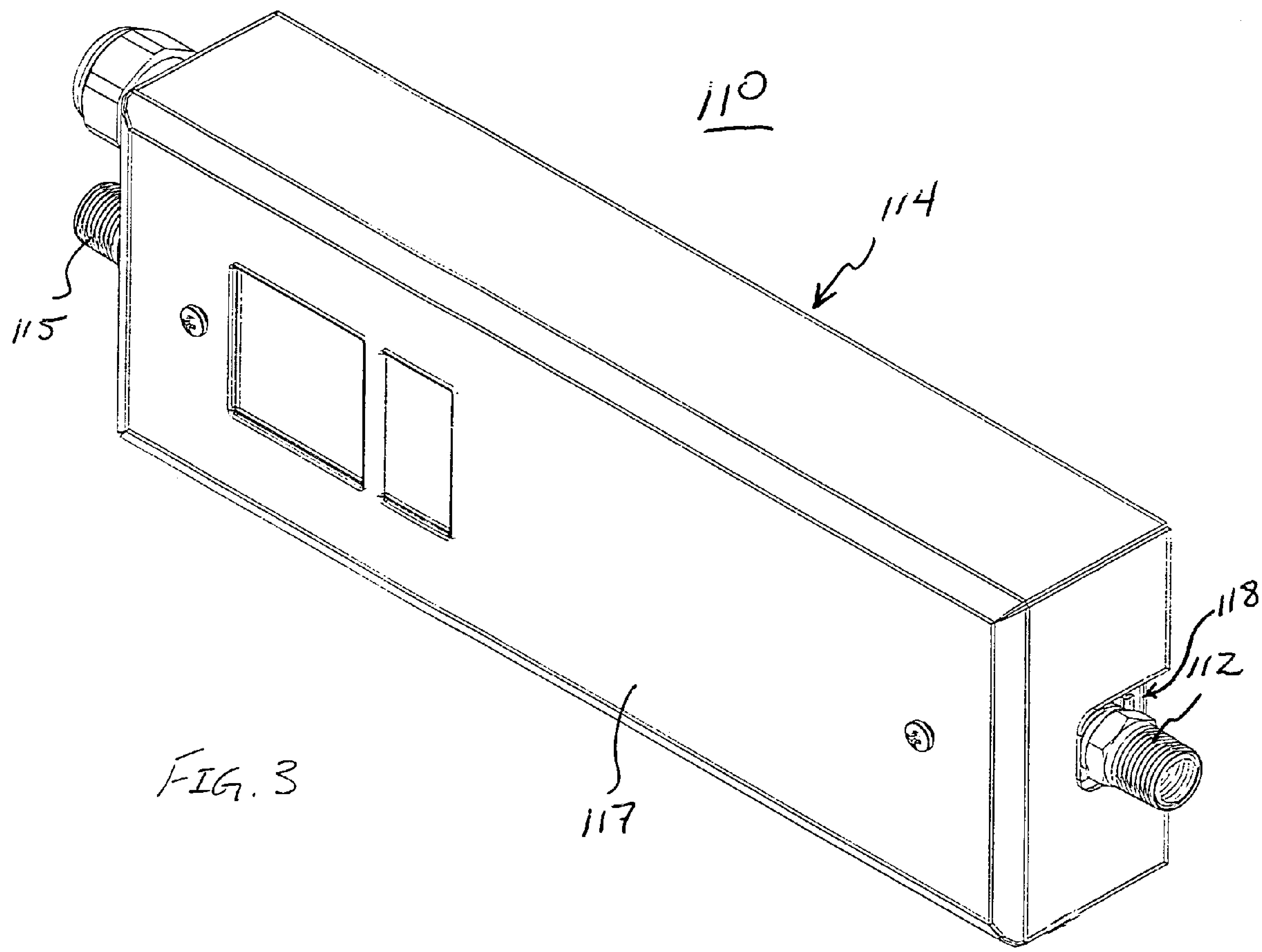


FIG. 3

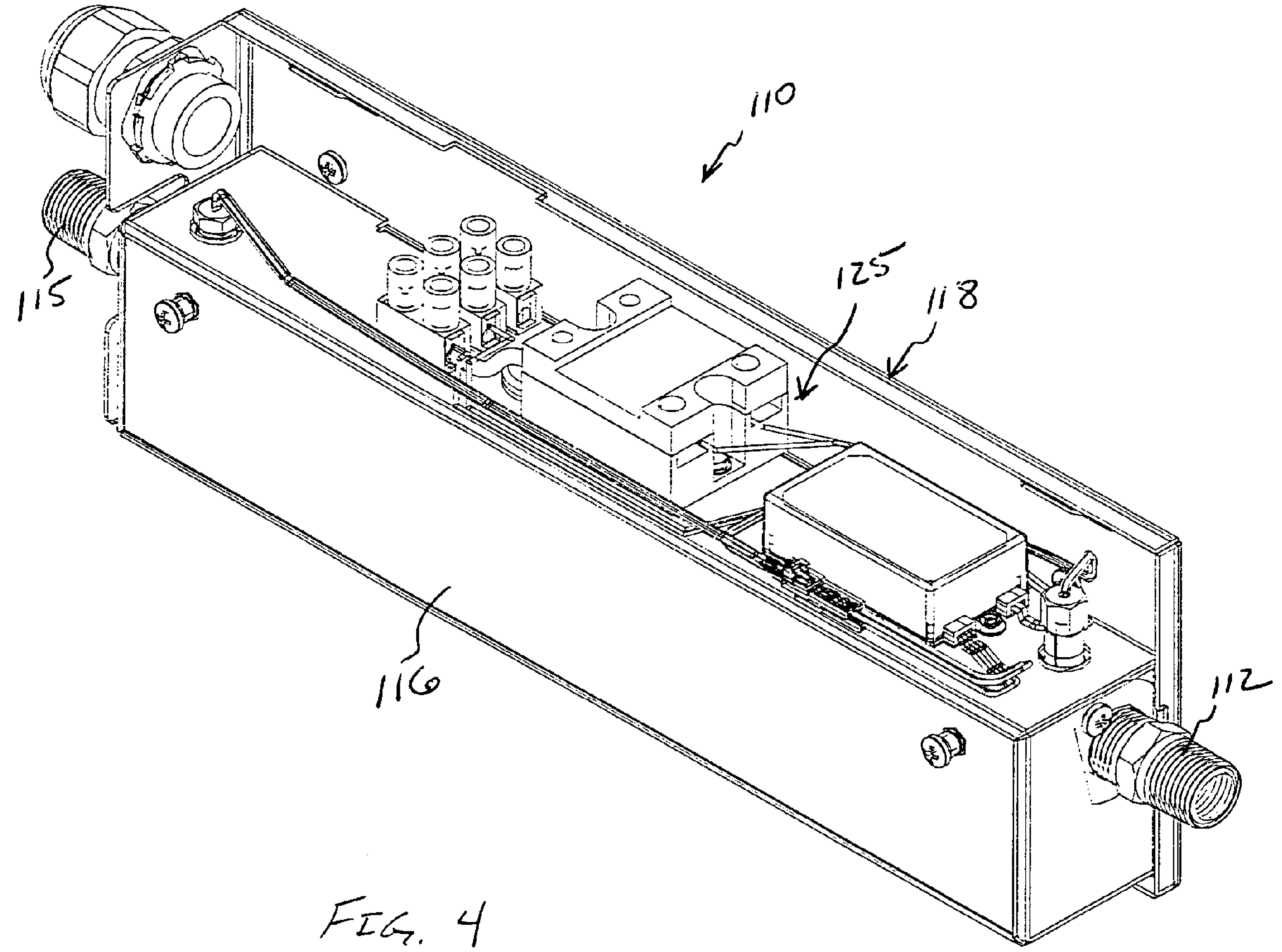
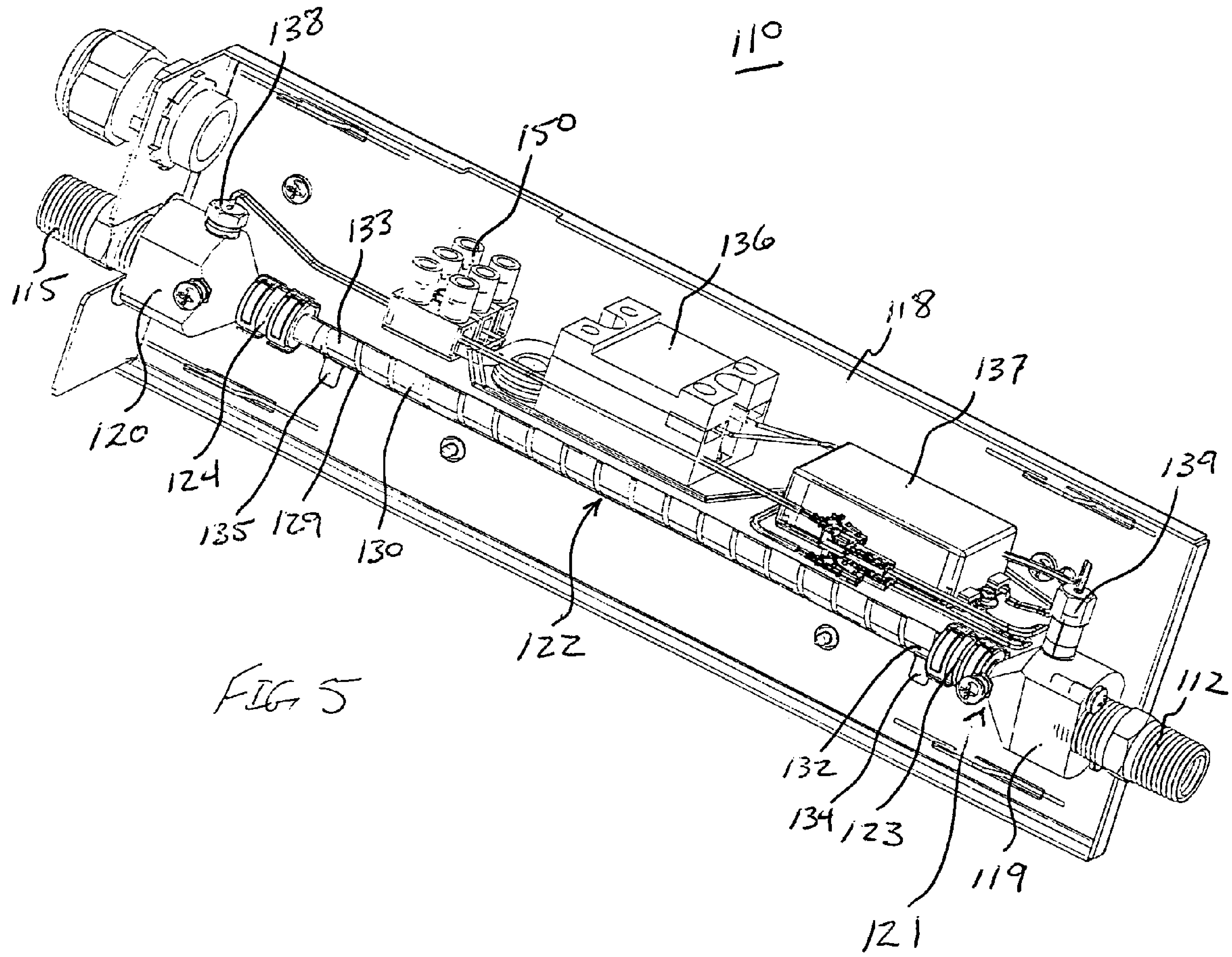


FIG. 4


110
138
150
133
136
115
118
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135
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112
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134
123
121
119

FIG 5

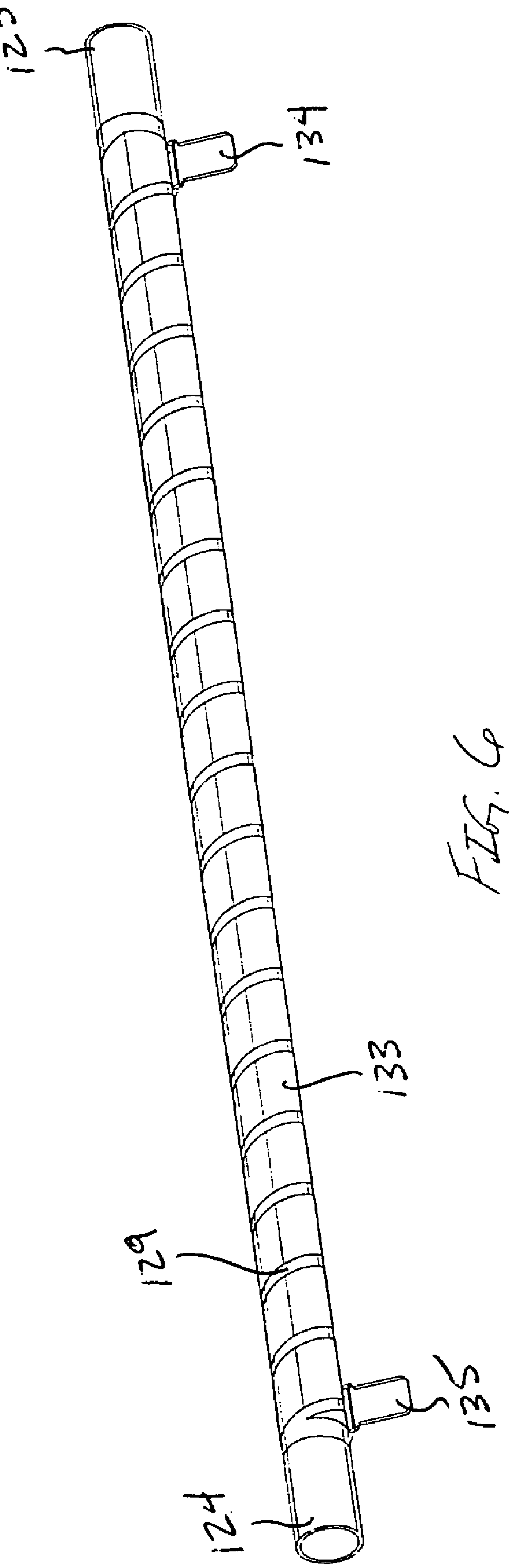
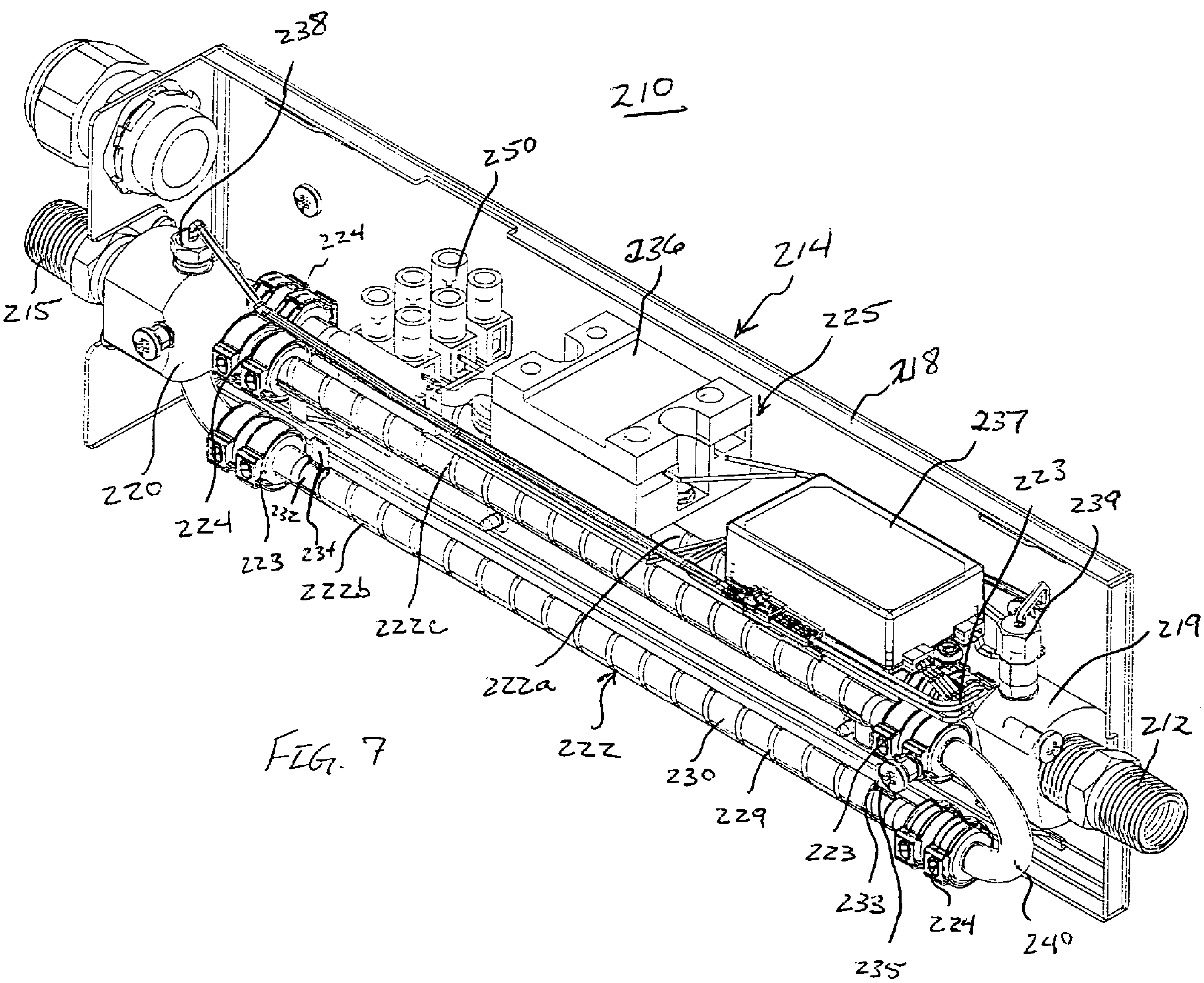


FIG. 6



210
238
250
224
236
214
225
215
218
237
220
224
223
232
234
223
239
222b
222c
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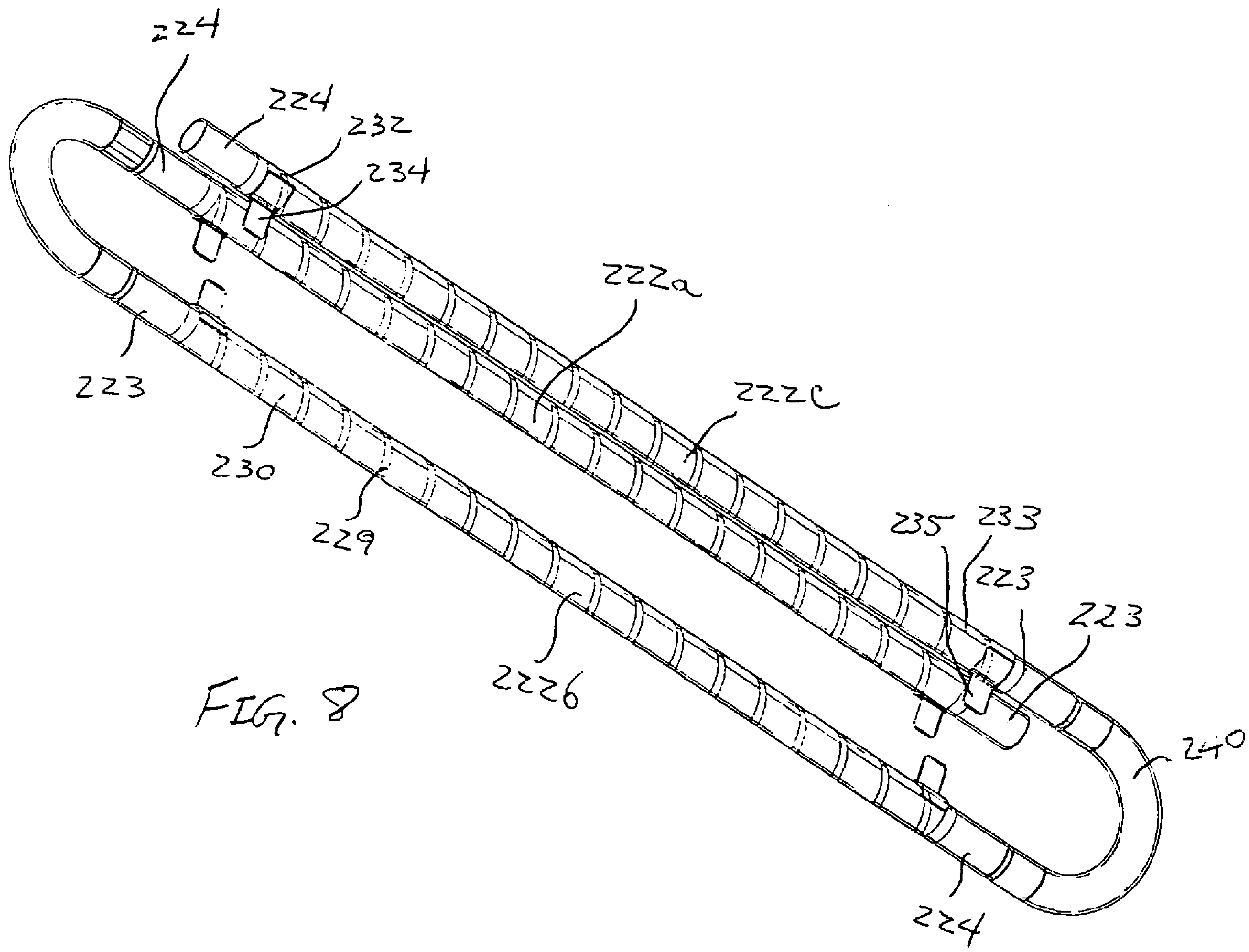
222a
212
222
230
229
223
233
224
240
235

FIG. 7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222a
222c
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229
222b
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233
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223
240
224

FIG. 8

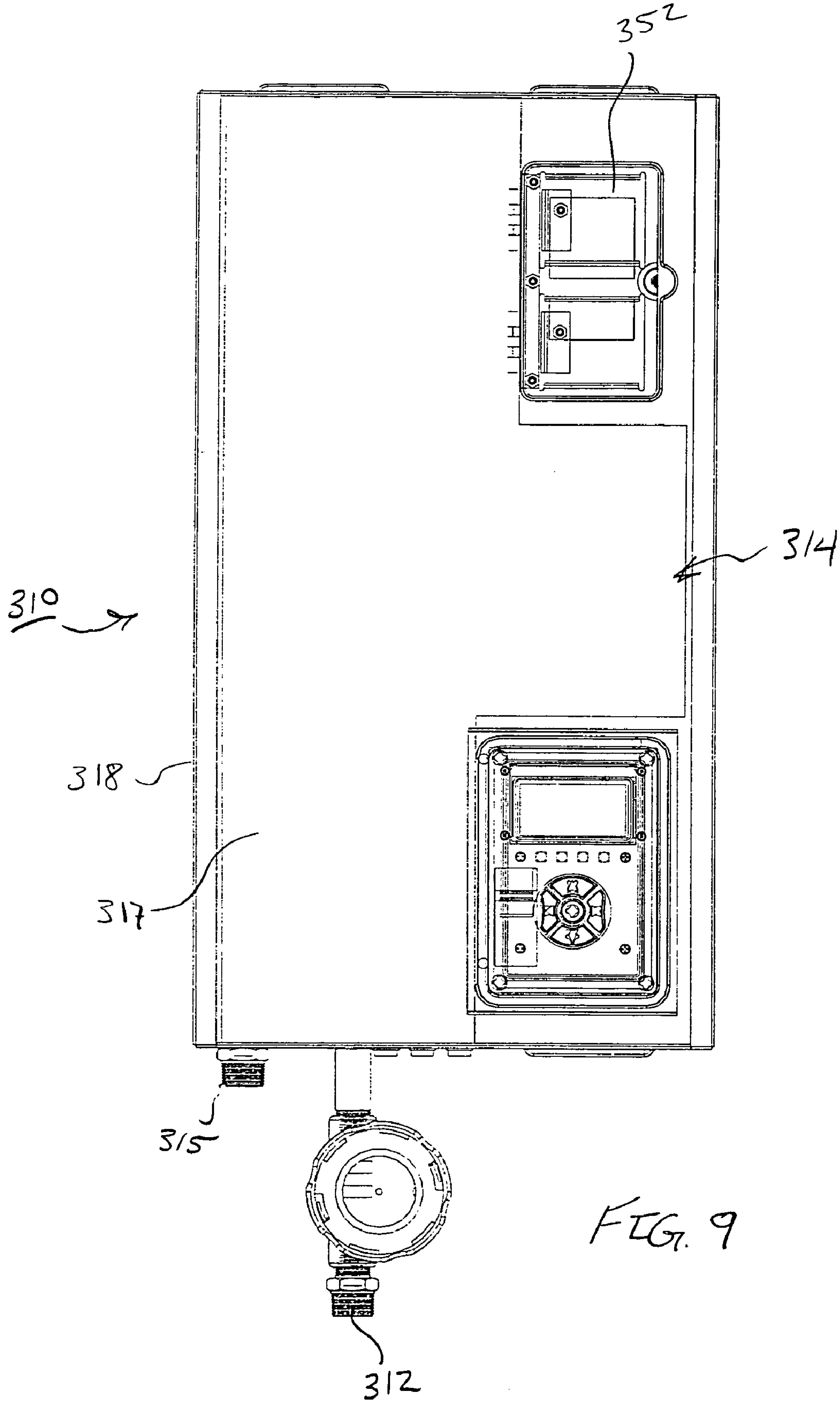


FIG. 9

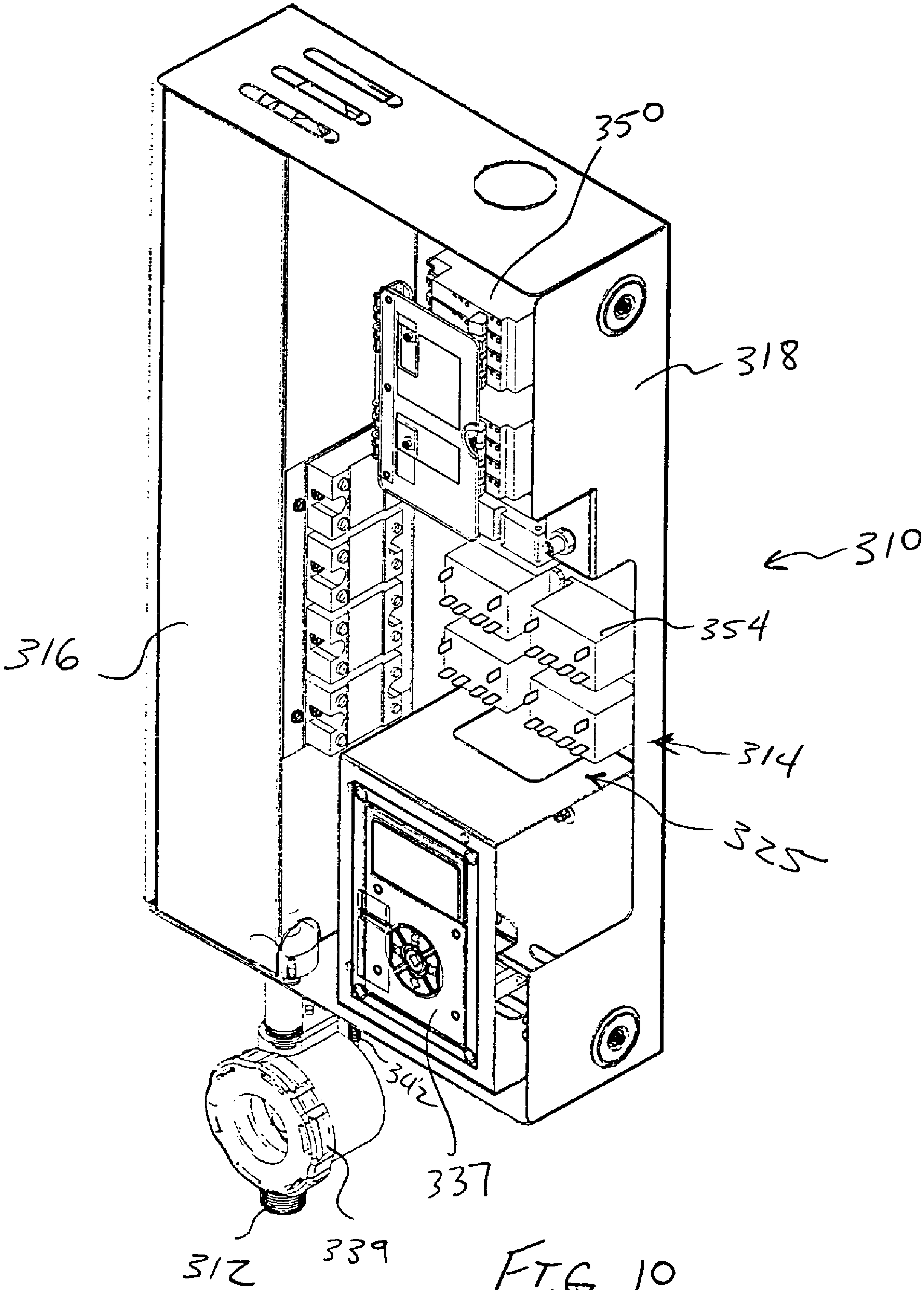


FIG. 10

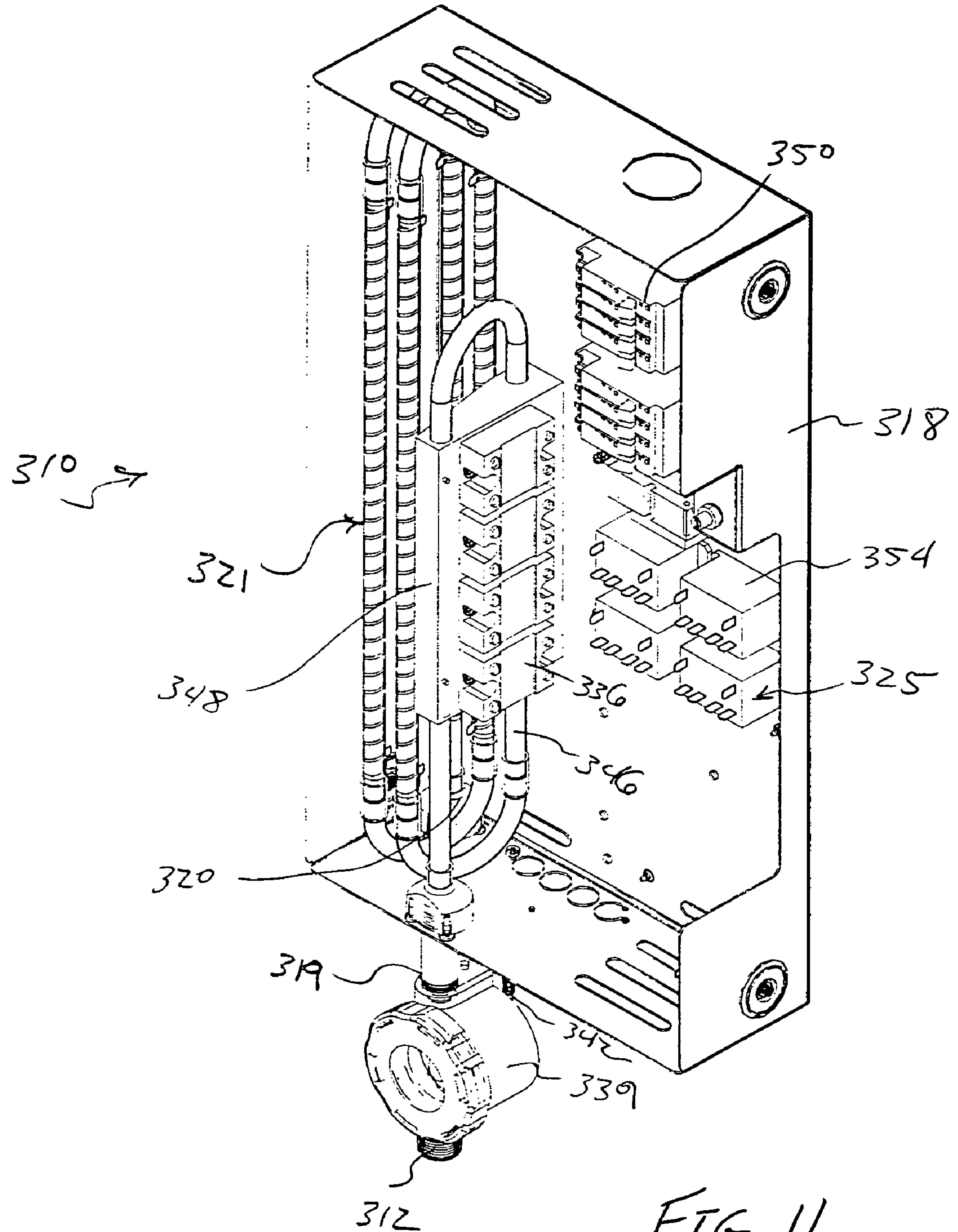
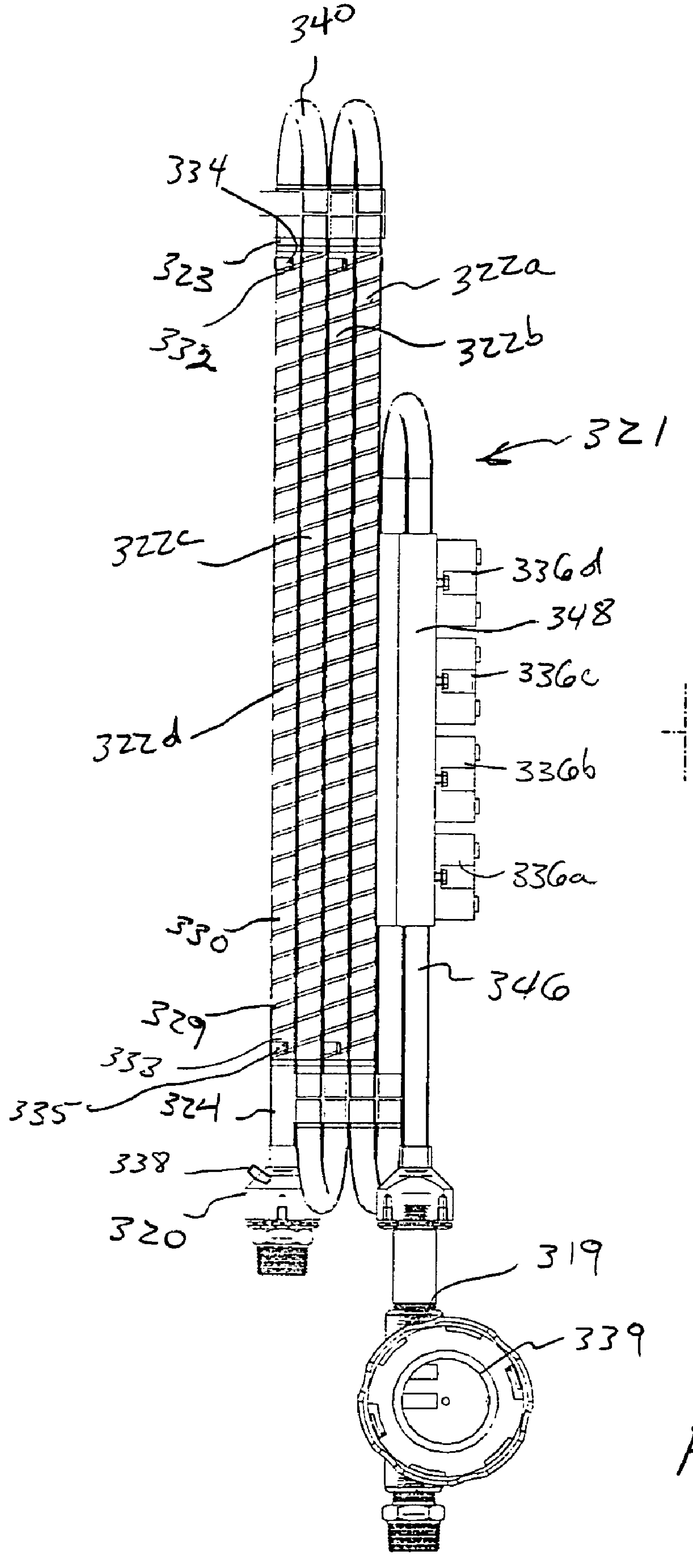


FIG. 11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322a
322b
321
322c
336d
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322d
336b
336a
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338
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319
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FIG. 12

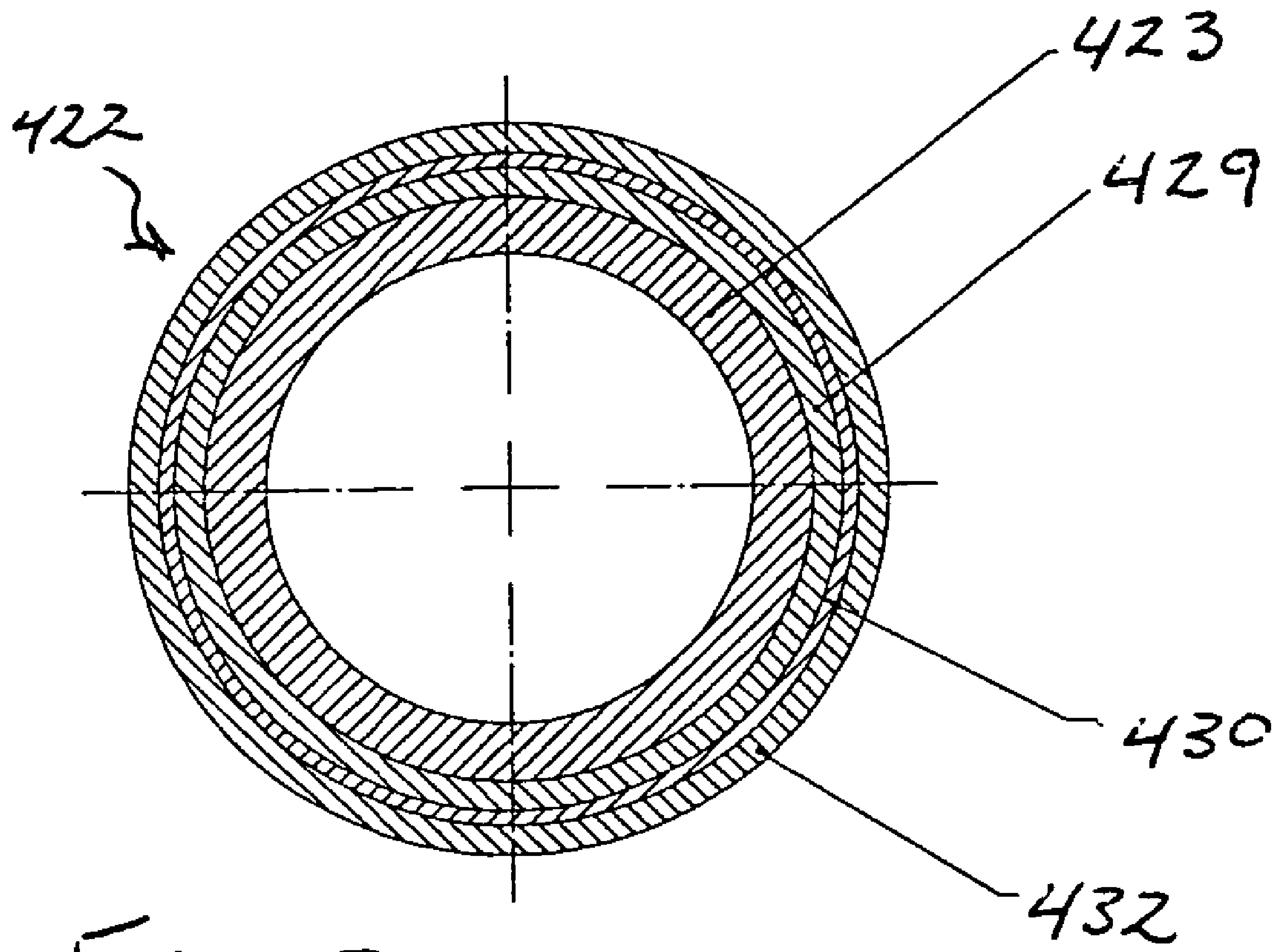

FIG. 13

FLUID HEATING SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

This application claims the benefit of U.S. Provisional Patent Application Ser. No. 60/604,080, filed 24 Aug. 2004.

FIELD OF THE INVENTION

This invention relates to fluid heaters.

More particularly, the present invention relates to tankless water heaters which heat water at the point of use or as a replacement to a water heating system.

BACKGROUND OF THE INVENTION

The need for heated fluids, and in particular heated water, has long been recognized. Conventionally, water has been heated by heating elements, either electrically or with gas burners, while stored in a tank or reservoir. While effective, energy efficiency and water conservation can be poor. As an example, water stored in a hot water tank is maintained at a desired temperature at all times. Thus, unless the tank is well insulated, heat loss through radiation can occur, requiring additional input of energy to maintain the desired temperature. In effect, continual heating of the stored water is required. Additionally, the tank is often positioned at a distance from the point of use, such as the hot water outlet. In order to obtain the desired temperature water, cooled water in the conduits connecting the point of use (outlet) and the hot water tank must be purged before the hot water from the tank reaches the outlet. This can often amount to a substantial volume of water.

Many of these problems have been overcome by the use of tankless water heaters. Heating water accurately and efficiently in a consistent and safe manner can be problematic with current tankless systems.

It would be highly advantageous, therefore, to remedy the foregoing and other deficiencies inherent in the prior art.

Accordingly, it is an object the present invention to provide a new and improved fluid heater.

Another objective of the present invention is to provide a tankless water heater.

And another object of the present invention is to provide a tankless water heater that can be employed as a point of use water heater and as a stand alone system.

SUMMARY OF THE INVENTION

Briefly, to achieve the desired objects of the present invention in accordance with a preferred embodiment thereof, provided is a fluid heating unit including a fluid heating tube assembly having a fluid heating tube with a tube formed of heat conducting material having an inlet end, an outlet end and a flow path extending therethrough. A dielectric coating is permanently bonded on an outer surface of the tube intermediate the inlet end and the outlet end, and a resistive layer is permanently bonded on the dielectric coating. A power distributor is coupled to the fluid heating tube assembly and coupleable to a power source. A switch is coupled to the power distributor and the fluid heating tube assembly, the switch being movable between an open position preventing current flow to the heating tube and a closed position allowing fluid flow to the heating tube.

In a specific aspect, the fluid heating unit includes a thermal sensor coupled to the fluid heating tube assembly, a flow sensor coupled to the fluid heating tube assembly, and a control mechanism receiving fluid flow data and fluid temperature data from the flow sensor and the thermal sensor, respectfully, and moving the switch between the open position and the closed position upon selected fluid flow and fluid temperature data.

In yet another aspect, the fluid heating tube assembly includes a second fluid heating tube with a tube formed of heat conducting material having an inlet end, an outlet end and a flow path extending therethrough. A dielectric coating is permanently bonded on an outer surface of the tube intermediate the inlet end and the outlet end, and a resistive layer is permanently bonded on the dielectric coating. The inlet end of the second fluid heating tube is coupled to the outlet end of the fluid heating tube, and the second fluid heating tube is coupled to the power distributor.

In additional aspects of the invention, the second heating tube is coupled to a second switch. The control mechanism receives fluid flow data and fluid temperature data from the flow sensor and the thermal sensor, respectfully, and moves the switch between the open position and the closed position upon selected fluid flow and fluid temperature data, and independently moves the second switch between the open position and the closed position upon selected fluid flow and fluid temperature data.

Also provided is a fluid heating tube including a tube formed of heat conducting material having a first end, a second end, and a flow path extending therethrough. A dielectric coating is permanently bonded on an outer surface of the tube, and a resistive layer is permanently bonded on the dielectric coating, wherein the tube, dielectric coating, and resistive layer have generally equivalent thermal coefficients of expansion.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and further and more specific objects and advantages of the invention will become readily apparent to those skilled in the art from the following detailed description of a preferred embodiment thereof, taken in conjunction with the drawings in which:

FIG. **1** is a sectional side view of a point of use water heating system according to the present invention;

FIG. **2** is a schematic diagram of a control circuit of the point of use water heating system of FIG. **1**;

FIG. **3** is a perspective view of another embodiment of a water heater according to the present invention;

FIG. **4** is a perspective view of the water heater of FIG. **3** with the cover removed;

FIG. **5** is a perspective view of the water heater of FIGS. **3** and **4** with the protective divider removed;

FIG. **6** is a perspective view of the heating tube of FIG. **5**;

FIG. **7** is a perspective view of another embodiment of a water heater according to the present invention;

FIG. **8** is a perspective view of a portion of the heating tube assembly of FIG. **7**; and

FIG. **9** is a perspective view of yet another embodiment of a water heater according to the present invention;

FIG. **10** is a perspective view of the water heater of FIG. **3** with the cover removed;

FIG. **11** is a perspective view of the water heater of FIGS. **3** and **4** with the protective divider removed;

FIG. **12** is a perspective view of the heating tube assembly of FIG. **11**; and

FIG. **13** is a sectional view of another embodiment of a heating tube.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Turning now to the drawings in which like reference characters indicate corresponding elements throughout the several views, attention is first directed to FIG. **1** which illustrates a point of use water heating system, generally designated **10**. System **10** includes a water supply conduit **12**, a water heating unit **14** and a hot water conduit **15**. Water is supplied to water heating unit **14** through water supply conduit **12**, and hot water is dispensed from water heating unit **14** through hot water conduit **15**. Water heating unit **14** includes a housing **18** carrying a heating tube assembly **21**. Heating tube assembly **21** includes a heating tube **22** extending between an inlet coupling **19** and an outlet coupling **20**. An inlet end **23** of heating tube **22** is coupled to inlet coupling **19** and an outlet end **24** of heating tube **22** is coupled to outlet coupling **20**. A control circuit **25** controls water heating unit **14** by monitoring water flow and water temperature. One skilled in the art will understand that fluids other than water can also be heating using the present invention.

Heating tube **22** includes a tube formed of heat conducting material such as copper, stainless steel, etc., having a dielectric coating **29** permanently bonded on an outer surface thereof and a resistive layer **30** permanently bonded on dielectric coating **29**. Resistive layer **30** will be understood to include many possible designs, such as being a layer substantially coating dielectric coating **29**, multiple strips extending from a contact, zigzag, curves, and the like, so as to form a continuous current path of resistive material along the tube on dielectric coating **29**. Dielectric coating **29** and resistive layer **30** are implemented using dielectric heating technology in either the sprayed or thick film application form. While other shapes/designs can be employed, resistive layer **30** is preferably formed of resistive material formed in a spiral pattern from inlet end **23** to outlet end **24**, to increase the uniformity of heat applied to the tube.

Upon application of current to resistive layer **30**, heat is generated. The generated heat is absorbed by the tube and water passing through the tube in a flow path from inlet end **23** to outlet end **24**. In order to prevent damage to dielectric coating **29** and resistive layer **30**, the materials selected for each have a thermal coefficient of expansion similar to the thermal coefficient of expansion of the heat conducting material used for the tube of heating tube **22**. Thus, as the material of the tube expands and contracts due to the influence of heat generated, dielectric coating **29** and resistive layer **30** each contract and expand sufficiently similarly to prevent damage thereto. One skilled in the art will understand that while the materials may not have identical thermal coefficients of expansion, they can have generally equivalent values which are sufficiently close to prevent major damage upon application of heat. The amount of heat generated is dependent upon the resistive material used as measured in watts per inch. The degree to which water passing through the tube is heated is dependent upon the heat generated, the surface area of the resistive layer, and the flow rate of the water through heating tube **22**.

With additional reference to FIG. **2**, control circuit **25** includes a thermal shut off switch **32**, a pressure differential switch **34**, and a solid-state relay **36**. A thermal sensor **38** is coupled to thermal shut off switch **32** and carried in outlet coupling **20** in fluid communication with water passing into hot water conduit **15**. A pressure port **39** is formed in each of inlet coupling **19** and outlet coupling **20**, and coupled to pressure differential switch **34**. Pressure differential switch **34** and thermal shut off switch **32** are connected in series to solid-state relay **36** to actuate relay **36** between an open position and a close position allowing current flow through and preventing current flow, respectively, to heating tube **22**. Thermal shut off switch **32** can be preset to a designated temperature at which current to resistive layer **30** is removed, halting heating of water in heating tube **22**. Additionally, pressure differential switch **34** along with pressure ports **39** form a flow sensor which prevents current from being applied to resistive **30** unless water is flowing through heating tube **22**.

Water flow is determined by a pressure differential between the ends of heating tube **22** indicating water flow. In other words, if water is not flowing through heating tube **22**, a constant pressure is maintained from inlet end and outlet end thereof. As, for example, a faucet is opened, water flow through heating tube **22** results in a higher pressure at the inlet end that the outlet end resulting from back pressure. Pressure differential switch **34** permits current to be applied to resistive layer **30** detects the flow of water through heating tube **22**. Since thermal shut off switch **32** and pressure differential switch **34** are coupled in series, the water heating unit **14** will not operate to heat water unless there is water flow as determined by pressure differential switch **34** and a predetermined temperature has not been reached as determined by thermal shut off switch **32**. If either the predetermined temperature is reached or water flow is shut off, heating tube **22** is turned off. A power distributor **50** receives power from a power source, not shown, for applying current to resistive layer **30** through solid-state relay **36** upon appropriate conditions as described previously.

It will be understood by those skilled in the art that control system **25** can be simply an on/off switch manually actuated, or more complex sensors and controls. Additionally, various combination of sensors collecting data such as water flow or temperature can be employed singally or in combination. Additional control features are described in connection with FIG. **3**.

Turning now to FIG. **3**, illustrated is another embodiment of a water heater system generally designated **110**. Water heater system **110** is a system which heats water as its flows through. Electrical power is conserved by heating water only as it is needed. System **110** includes a water supply conduit **112**, a water heating unit **114** and a hot water conduit **115**. Water is supplied to water heating unit **114** through water supply conduit **112**, and hot water is dispensed from water heating unit **114** through hot water conduit **115**. Water heating unit **14** includes housing **118** closed by a cover **117**.

Referring to FIG. **4**, water heater system **110** is illustrated with cover **117** removed. Housing **118** includes apertures on opposing ends to permit passage of supply conduit **112** and hot water conduit **115** therethrough. Housing **118** also includes a protective divider **116** for separating a heating tube assembly **121** (FIG. **5**) from a control circuit **125**.

FIG. **5** illustrates water heater system **110** with divider **116** removed. Heating tube assembly **121** includes an inlet coupling **119** and an outlet coupling **120** coupling heating tube **122** between supply conduit **112** and hot water conduit **115**. Heating tube **122** extends between inlet coupling **119** and outlet coupling **120** with an inlet end **123** coupled to inlet coupling **119** and an outlet end **124** coupled to outlet coupling **120**. Control circuit **125** controls water heating unit **114** by monitoring water flow and water temperature.

With additional reference to FIG. **6**, heating tube **122** includes a tube formed of heat conducting material such as copper, stainless steel, etc., having a dielectric coating **129** permanently bonded on an outer surface thereof and a resistive layer **130** permanently bonded on dielectric coating **129**. Dielectric coating **129** and resistive layer **130** are substantially the same as those discussed in connection with heating tube **22** and thus will not be described in further detail. Resistive layer **130** has an end **132** and an opposing end **133**. Resistive layer **130** is formed preferably in a spiral pattern with end **132** proximate inlet end **123** and opposing end **133** proximate outlet end **124**. Upon application of current to resistive layer **130**, heat is generated. Current is applied through a contact **134** extending from resistive layer **130** proximate end **132** and a contact **135** proximate end **133**. The generated heat is absorbed by the tube and water passing through the tube in a flow path from inlet end **123** to outlet end **124**.

Control circuit **125** includes a switch, which in this embodiment is a solid-state relay **136** and a control module **137**. A thermal sensor **138** is coupled to heating tube assembly **121** so as to determine the temperature of outflowing fluid from the flow path. A flow sensor **139** is coupled to heating tube assembly **121** so as to determine the rate of flow, or if there is flow of fluid through the flow path. In each case, the sensors can be mounted to heating tube **122**, inlet coupling **119**, or outlet coupling **120**, depending on what is being sensed. Various types of sensors for measuring temperature and flow can also be employed, some of which may have elements in the flow path or only adjacent thereto. In the present embodiment, thermal sensor **138** is carried by outlet coupling **120** and flow sensor **139** is carried by inlet coupling **119**.

Data from thermal sensor **138** and flow sensor **139** are received by control module **137** which, upon appropriate data, actuates relay **136**. Solid-state relay **136** is switched between a closed position and an open position allowing current flow through and preventing current flow, respectively, to heating tube **122**. Control module **137** can be preset to a designated temperature at which current to resistive layer **130** is removed by opening relay **136**, halting heating heating tube **122**. Additionally, control module **137** can prevent current from being applied to resistive layer **130** unless water is flowing through heating tube **122**. A power distributor **150** receives power from a power source, not shown, for applying current to resistive layer **130** through solid-state relay **136** upon appropriate conditions as described previously.

Turning now to FIG. **7**, yet another embodiment of a water heater system generally designated **210** is illustrated. System **210** includes a water supply conduit **212**, a water heating unit **214** and a hot water conduit **215**. Water heating unit **214** includes housing **218** closed by a cover which is not shown, but generally similar to that of system **110**. Housing **218** includes apertures on opposing ends to permit passage of supply conduit **212** and hot water conduit **215** therethrough. As with system **110**, housing **218** can include a protective divider.

Water heating unit **214** includes a heating tube assembly **221** and a control circuit **225**. Control circuit **225** is substantially identical to control circuit **125** with slight differences due to differences in heating tube assembly **221**. Heating tube assembly **221** includes an inlet coupling **219** and an outlet coupling **220** coupling a plurality of heating tubes **222** between supply conduit **212** and hot water conduit **215**. Control circuit **225** controls heating tube assembly **221** by monitoring water flow and water temperature.

With additional reference to FIG. **8**, heating tube assembly **222** includes a plurality of heating tubes, designated **222***a*, **222***b*, and **222***c*. Each heating tube **222***a*, **222***b*, and **222***c* includes a tube formed of heat conducting material such as copper, stainless steel, etc., and having an inlet end **223** and an outlet end **224**. A dielectric coating **229** is permanently bonded on an outer surface of the tube and a resistive layer **230** is permanently bonded on dielectric coating **229**. Resistive layer **230** is formed of electrically resistive material available from known vendors and having an end **232** and an opposing end **233**. Resistive layer **230** is preferably formed in a spiral pattern with end **232** proximate inlet end **223** and opposing end **233** proximate outlet end **224**. Heating tubes **222**, dielectric coating **229** and resistive layer **230** are substantially the same as those discussed in connection with heating tube **22** and **122**, and thus will not be described in further detail. It will be understood that while three heating tubes are employed in the present embodiment, substantially any number of heating tube from one to a great many can be employed in the various embodiments.

Current is applied through a contact **234** extending from resistive layer **230** proximate end **232** and a contact **235** proximate end **233** of each heating tube **222**. The generated heat is absorbed by the tube and water passing through the tube in a flow path from inlet end **223** to outlet end **224**. Heating tubes **222** are coupled in series. Thus, inlet end **223** of heating tube **222***a* is coupled to inlet coupling **219** and outlet end **224** is coupled to inlet end **223** of heating tube **222***b*. Outlet end **224** of heating tube **222***b* is coupled to inlet end **223** of heating tube **222***c*, with outlet end **224** of heat tube **222***c* coupled to outlet coupling **220**. Heating tubes **222***a*, **222***b*, and **222***c* can be coupled in various manners, such as employing header blocks and the like, or, as illustrated herein, using curved tube elements **240** such as to place each heating tube **222** substantially parallel to one another. This can greatly reduce the footprint of heating unit **214**.

Control circuit **225** includes a switch such as solid-state relay **236** and a control module **237**. A thermal sensor **238** is is coupled to heating tube assembly **221** so as to determine the temperature of outflowing fluid from the flow path. A flow sensor **239** is coupled to heating tube assembly **221** so as to determine the rate of flow, or simply if there is or is not a flow of fluid through the flow path. In this embodiment, thermal sensor is carried by outlet coupling **220** to determine the temperature of water passing into hot water conduit **215**. Flow sensor **239** is carried by inlet coupling **219** to determine if there is a flow of water passing into heating tube assembly **221** from supply conduit **212**. Data from thermal sensor **238** and flow sensor **239** are received by control module **237** which, upon appropriate data, actuates relay **236**. Solid-state relay **236** is switched between a closed position and an open position allowing current flow and preventing current flow, respectively, to heating tube assembly **221**. Since this embodiment includes a plurality of heating tubes **222**, solid state relay is coupled to each to provide current to contacts **234** and **235**.

Turning now to FIG. **9**, yet another embodiment of a water heater system generally designated **310** is illustrated. Water heater system **310** is a system which heats water as its flows through, but which can be employed to replace an existing water heating system for an entire house, building, and the like. In effect, system **310** can be of sufficient capacity to supply hot water (or other fluids) to, for example, and entire house as opposed to a single point of use. Electrical power is conserved by heating water only as it is needed. As water needs are increased, increasing amounts of energy are added to the flowing water to reach a desired temperature. System **310** includes a water supply conduit **312**, a water heating unit **314** and a hot water conduit **315**.

Water is supplied to water heating unit **314** through water supply conduit **312**, and hot water is dispensed from water heating unit **314** through hot water conduit **315**. Water heating unit **314** includes housing **318** closed by a cover **317**.

Referring to FIG. **10**, water heater system **310** is illustrated with cover **317** removed. Housing **318** includes a protective divider **316** for separating a heating tube assembly **321** (FIG. **11**) from a control circuit **325**.

FIG. **11** illustrates water heater system **310** with divider **316** removed. Heating tube assembly **321** includes an inlet coupling **319** and an outlet coupling **320** coupling a plurality of heating tubes **322** between supply conduit **312** and hot water conduit **315**. Control circuit **325** controls heating tube assembly **221** by monitoring water flow and water temperature.

With additional reference to FIG. **12**, heating tube assembly **322** includes a plurality of heating tubes, designated **322***a*, **322***b*, **322***c*, and **322***d*. Each heating tube **322***a*, **322***b*, **322***c*, and **322***d* includes a tube formed of heat conducting material such as copper, stainless steel, etc., and having an inlet end **323** and an outlet end **324**. A dielectric coating **329** is permanently bonded on an outer surface of the tube and a resistive layer **330** is formed on dielectric coating **329**. Resistive layer **330** is formed of electrically resistive material available from known vendors and having an end **332** and an opposing end **333**. Resistive layer **330** is preferably formed in a spiral pattern with end **332** proximate inlet end **323** and opposing end **333** proximate outlet end **324**. Heating tubes **322**, dielectric coating **329** and resistive layer **330** are substantially the same as those discussed in connection with heating tube **22**, **122**, and **222** and thus will not be described in further detail.

Current is applied through a contact **334** extending from resistive layer **330** proximate end **332** and a contact **335** proximate end **333** of each heating tube **322**. The generated heat is absorbed by the tube and water passing through the tube in a flow path from inlet end **323** to outlet end **324**. Heating tubes **322** are preferably coupled in series. Thus, inlet end **323** of heating tube **322***a* is coupled to inlet coupling **319** and outlet end **324** is coupled to inlet end **323** of heating tube **322***b*. Outlet end **324** of heating tube **322***b* is coupled to inlet end **323** of heating tube **322***c*, with outlet end **324** of heat tube **322***c* coupled to inlet end **323** of heating tube **322***d*. Outlet end **324** of heating tube **322***d* is coupled to outlet coupling **320**. Heating tubes **322***a*, **322***b*, **322***c*, and **322***d* can be coupled in various manners, such as employing header blocks and the like, or, as illustrated herein, using curved tube elements **340** such as to place each heating tube **322** substantially parallel to one another. This can greatly reduce the footprint of heating unit **314**.

Referring back to FIGS. **10**, **11**, and **12**, control circuit **325** includes a plurality of switches, such as solid-state relays **336***a, b, c*, and *d* associated with heating tubes **322***a, b, c*, and *d*, respectively, and a control module **337**. A thermal sensor **338** is is coupled to heating tube assembly **321** so as to determine the temperature of outflowing fluid from the flow path. A flow sensor **339** is coupled to heating tube assembly **321** so as to determine the rate of flow, or simply if there is or is not a flow of fluid through the flow path. In this embodiment, thermal sensor is carried by outlet coupling **320** to determine the temperature of water passing into hot water conduit **315**. Flow sensor **339** is carried by inlet coupling **319** to determine if there is a flow of water passing into heating tube assembly **321** from supply conduit **312**. Data from thermal sensor **338** and flow sensor **339** are received by control module **337** which, upon appropriate data, actuates selected ones of relays **336***a–d*. Solid-state relays **336***a–d* are switched between a closed position and an open position allowing current flow and preventing current flow, respectively, to corresponding heating tubes **322***a–d*. Since this embodiment includes a plurality of heating tubes, a solid state relay is coupled to each to independently provide current to contacts **334** and **335**.

A power distributor includes a terminal and breaker switch combination **350** to provide safety and reduce associated elements needed for installation. Breakers **350** can be accessed through a hinged panel **352** (FIG. **9**) in cover **317**. No separate or outside breaker box is necessary for the installation of system **310**. Control module **337** receives water flow and water temperature data, controlling heater tubes **322***a–d* by actuating selected ones of or all of solid-state relay switches **336***a–d*. System **310**, in this embodiment, also includes mechanical relays **354***a, b, c*, and *d*, one for each solid state relay **336***a–d*, which act as safety shut-offs when a predetermined temperature is equaled or exceeded. These relays are coupled to thermal sensor **338** and flow sensor **339**, but not coupled to control module **337** and are thus independent therefrom. Electrical power runs from breakers **350** through mechanical relays **354***a–d* to solid state relays **336***a–d*, respectively. When signaled from control module **337**, relays **336***a–d* provide power to heating tubes **322***a–d*, respectively, and independently.

With reference to FIGS. **10** and **11**, data is provided to control module **337** by flow sensor **339** carried by inlet coupling **319**. In this embodiment, flow sensor **339** is a paddle wheel pulse flow sensor which allows the volume of water entering heater tube assembly **321** to be measured. In addition to thermal sensor **338** measuring the outlet fluid temperature, there can be included an inlet temperature sensor **342** carried by inlet coupling **319** to measure the temperature of the incoming fluid. Temperature sensors **338** and **342** allow the temperature of water entering and exiting heating tube assembly **321** to be measured. This data is employed by control module **337** to activate one or more heating tubes **322***a–d*, activated through solid state relay switches **336***a–d*. Various methodologies can be employed to control and adjust the operation of the heating tubes. This is typically controlled by software within control module **337**.

Still referring to FIGS. **11** and **12** solid state relays **336***a–d* generate heat as they are used. This heat can build up, and can degrade the operation of the relays over time. The heat generated by relays **336** is generally wasted heat. System **310** employs the heat generated by relays **336** to add energy to heating tube assembly **321**. Additional piping **346** is coupled between inlet end **324** of heating tube **322***a* and inlet coupling **319**. Piping **346** runs through a heatsink block **348** to which relays **336** are attached. As relays **336** generate heat energy, heatsink block **348** transmits the heat to piping **346** and thus incoming fluid passing therethrough. In this manner, heat is pulled from relays **336** and added to the heating tube assembly **321**.

Fluid heating system **310** can include multiple sensors, for providing data to control module **337** allowing for greater control and adjustability. Additionally, control module **337** can be employed as disclosed in co-pending application entitled, "Modular Tankless Water Heater Control Circuitry and Method of Operation", Ser. No. 11/080,120, filed 4 Mar. 2005 and included herein by reference.

Another embodiment of a heating tube generally designated Heating tube **422** is illustrated in cross-section. Heating tube **422** is substantially similar to those heating tubes previously described, including a tube **423** formed of heat conducting material such as copper, stainless steel, etc., having a dielectric coating **429** permanently bonded on an outer surface thereof and a resistive layer **430** permanently bonded on dielectric coating **429**. In this embodiment, however, an additional layer is provided. Another dielectric layer **432** is formed overlying resistive layer **430**. Dielectric layer **432** is employed as a protective coating preventing inadvertent injury which may result from contact with resistive layer **430** when current is flowing therethrough.

Various changes and modifications to the embodiments herein chosen for purposes of illustration will readily occur to those skilled in the art. To the extent that such modifications and variations do not depart from the spirit of the invention, they are intended to be included within the scope thereof, which is assessed only by a fair interpretation of the following claims.

The invention claimed is:

1. A fluid heating unit comprising:

a fluid heating tube assembly including a first fluid heating tube with a tube formed of heat conducting material having an inlet end, an outlet end and a flow path extending therethrough, a dielectric coating permanently bonded on an outer surface of the tube intermediate the inlet end and the outlet end, and a resistive layer formed on the dielectric coating, and a second fluid heating tube with a tube formed of heat conducting material having an inlet end, an outlet end and a flow path extending therethrough, a dielectric coating permanently bonded on an outer surface of the tube intermediate the inlet end and the outlet end, and a resistive layer formed on the dielectric coating, the inlet end of the second fluid heating tube coupled to the outlet end of the first fluid heating tube;

a power distributor coupled to the fluid heating tube assembly and coupleable to a power source;

a first switch coupled to the power distributor and the first fluid heating tube, the first switch movable between an open position preventing current flow to the first fluid heating tube and a closed position allowing current flow to the first fluid heating tube; and

a second switch coupled to the power distributor and the second fluid heating tube, the second switch movable between an open position preventing current flow to the second fluid heating tube and a closed position allowing current flow to the second fluid heating tube.

2. A fluid heating unit as claimed in claim **1** further including:

a thermal sensor coupled to the fluid heating tube assembly; and

a control mechanism receiving fluid temperature data from the thermal sensor and moving the first switch between the open position and the closed position upon selected fluid temperature data and moving the second switch between the open position and the closed position upon selected fluid temperature data.

3. A fluid heating unit as claimed in claim **1** further including:

a flow sensor coupled to the fluid heating tube assembly; and

a control mechanism receiving fluid flow data from the flow sensor and moving the first switch between the open position and the closed position upon selected fluid flow data and moving the second switch between the open position and the closed position upon selected fluid temperature data.

4. A fluid heating unit as claimed in claim **1** wherein the first switch is a first relay coupled between the first fluid heating tube and the power distributor, and the control mechanism is coupled to the first relay for actuating the first relay to control current flow from the power distributor to the first fluid heating tube and the second switch is a second relay coupled between the second fluid heating tube and the power distributor, and the control mechanism is coupled to the second relay for actuating the second relay to control current flow from the power distributor to the second fluid heating tube.

5. A fluid heating unit as claimed in claim **1** further including:

a thermal sensor coupled to the fluid heating tube assembly;

a flow sensor coupled to the fluid heating tube assembly; and

a control mechanism receiving fluid flow data and fluid temperature data from the flow sensor and the thermal sensor, respectfully, moving the first switch between the open position and the closed position upon selected fluid flow and fluid temperature data, and moving the second switch between the open position and the closed position upon selected fluid flow and fluid temperature data.

6. A fluid heating unit as claimed in claim **5** wherein the control mechanism includes a thermal shut off switch coupled to the thermal sensor, and a pressure differential switch coupled to the flow sensor, the thermal shut off switch and pressure differential switch each being coupled to the first switch and the second switch.

7. A fluid heating unit as claimed in claim **1** wherein the resistive layer of the first fluid heating tube and the second fluid heating tube is formed in a spiral pattern about the tube.

8. A fluid heating unit as claimed in claim **1** further including piping coupled to the inlet end of the first fluid heating tube, a heat sink block carried by the piping, and the first switch and the second switch coupled to the heat sink block.

9. A fluid heating system comprising:

a fluid supply conduit;

a hot fluid conduit;

a fluid heating tube assembly including an inlet coupling coupled to the fluid supply conduit, an outlet coupling coupled to the hot fluid conduit, and a first fluid heating tube coupled to the inlet coupling and including a tube formed of heat conducting material, a dielectric coating permanently bonded on an outer surface of the tube, and a resistive layer formed on the dielectric coating, and a second fluid heating tube coupled between the first fluid heating tube and the outlet coupling, the second fluid heating tube including a tube formed of heat conducting material, a dielectric coating permanently bonded on an outer surface of the tube, and a resistive layer formed on the dielectric coating;

a power distributor coupled to the fluid heating tube assembly and coupleable to a power source;

a first switch coupled between the power distributor and the first fluid heating tube, the first switch movable between an open position preventing current flow to the first fluid heating tube and a closed position allowing current flow to the firstfluid heating tube; and

a second switch coupled between the power distributor and the second fluid heating tube, the second switch movable between an open position preventing current flow to the second heating tube and a closed position allowing current flow to the second heating tube.

10. A fluid heating system as claimed in claim **9** further including:

a thermal sensor coupled to the fluid heating tube assembly; and

a control mechanism receiving fluid temperature data from the thermal sensor and moving the first switch between the open position and the closed position upon selected fluid temperature data and moving the second switch between the open position and the closed position upon selected fluid temperature data.

11. A fluid heating system as claimed in claim **9** further including:

a flow sensor coupled to the fluid heating tube assembly; and

a control mechanism receiving fluid flow data from the flow sensor and moving the first switch between the open position and the closed position upon selected fluid flow data and moving the second switch between the open position and the closed position upon selected fluid temperature data.

12. A fluid heating system as claimed in claim **9** wherein the first switch is a first relay coupled between the first fluid heating tube and the power distributor, and the control mechanism is coupled to the first relay for actuating the first relay to control current flow from the power distributor to the first fluid heating tube and the second switch is a second relay coupled between the second heating tube and the power distributor, and the control mechanism is coupled to the second relay for actuating the second relay to control current flow from the power distributor to the second fluid heating tube.

13. A fluid heating system as claimed in claim **9** further including:

a thermal sensor coupled to the fluid heating tube assembly;

a flow sensor coupled to the fluid heating tube assembly; and

a control mechanism receiving fluid flow data and fluid temperature data from the flow sensor and the thermal sensor, respectfully, moving the first switch between the open position and the closed position upon selected fluid flow and fluid temperature data, and moving the second switch between the open position and the closed position upon selected fluid flow and fluid temperature data.

14. A fluid heating system as claimed in claim **13** wherein the control mechanism includes a thermal shut off switch coupled to the thermal sensor, and a pressure differential switch coupled to the flow sensor, the thermal shut off switch and pressure differential switch each being coupled to the first switch and the second switch.

15. A fluid heating system as claimed in claim **14** wherein the flow sensor includes a first pressure sensor mounted in the inlet coupling, and a second pressure sensor mounted in the outlet coupling, each coupled to the pressure differential switch.

16. A fluid heating system as claimed in claim **9** wherein the resistive layer of the first fluid heating tube and the second fluid heating tube is formed in a spiral pattern about the tube.

17. A fluid heating system as claimed in claim **9** further including piping coupled between the inlet coupling and the first fluid heating tube, a heat sink block carried by the piping, and the first switch and the second switch coupled to the heat sink block.

18. A fluid heating tube comprising:

a tube formed of heat conducting material having a first end, a second end, and a flow path extending therethrough;

a dielectric coating permanently bonded on an outer surface of the tube; and

a resistive layer formed on the dielectric coating;

wherein the tube, dielectric coating, and resistive layer have generally equivalent thermal coefficients of expansion.

19. A fluid heating tube as claimed in claim **18** wherein the resistive layer is formed in a spiral pattern about the tube.

20. A fluid heating tube as claimed in claim **18** further comprising a first contact extending from the resistive layer and a second contact extending from the resistive layer.

21. A fluid heating tube as claimed in claim **18** further comprising:

a second tube formed of heat conducting material having a first end, a second end, and a flow path extending therethrough, one of the first end and the second end of the second tube coupled to one of the first end and the second end of the tube;

a dielectric coating permanently bonded on an outer surface of the second tube; and

a resistive layer formed on the dielectric coating of the second tube;

wherein the second tube, dielectric coating, and resistive layer have generally equivalent thermal coefficients of expansion.

22. A fluid heating tube as claimed in claim **21** wherein the second tube is coupled to the tube by a curved tube element such as to place the second tube substantially parallel to the tube.

23. A fluid heating tube as claimed in claim **21** wherein the resistive layer of the second tube is formed in a spiral pattern about the second tube.

24. A fluid heating tube as claimed in claim **21** further comprising a first contact extending from the resistive layer of the second tube and a second contact extending from the resistive of the second tube.

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